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Evaluation of non-sampling errors in the US National Swine Survey

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Abstract

On-farm data collection consists of a dynamic interaction between the interviewer and respondent via a questionnaire. Non-sampling errors introduced by these sources during the measurement process often account for a greater proportion of the total survey error than sampling error alone. A two pronged approach was used to evaluate non-sampling errors in the National Animal Health Monitoring System's National Swine Survey. First, results from two supplemental questionnaires, administered to field coordinators and interviewers of the National Swine Survey, were used to assess correlates of non-sampling errors. Second, since questionnaires contained multiple indicators of the same underlying concept, an index of inconsistency was used to quantify the level of response error for several variables.

Bias due to the ecologic fallacy was shown by elevated estimates of response error for several indicators of preventive practices. Correlates of respondent error included the presence of multiple respondents for at least one interview for more than half of the interviewers. Correlates of interviewer error included demographic characteristics of interviewers and variations in question administration. Evidence corroborates the idea that survey questions should be unambiguous in wording and simple in structure. Results led to specific recommendations for future questionnaire design and interviewer training. The manifestation of many correlates of non-sampling error support the need for assessment of total survey error in large surveys.

Keywords: Pig; Non-sampling errors; NAHMS; USA

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1. Introduction

In 1989, with the initiation of the National Swine Survey (NSS), the National Animal Health Monitoring System (NAHMS) launched its first nationally coordinated effort to obtain statistically reliable data on disease occurrence, production parameters, and the frequency of management practices and facility characteristics (Hueston, 1990a; King, 1990). A cooperative effort of practitioners, industry, university, Extension Service, and other government agencies was coordinated by NAHMS, leading to the final design of the NSS. The National Agricultural Statistical Service (NASS) provided expertise in frame construction, sampling methods, questionnaire design, and interviewing procedures. The probability sampling design used for the NSS was known to be a statistically valid study design and permits the estimation of measured variables for the national population.

Traditionally, the sampling variance of these statistics will also be calculated and used as an estimate of 'the error' in the study. However, many other factors contribute to the quality of data collected besides that due to random variation (Converse and Traugott, 1986). The conduct of a survey involves the interactions between interviewers, respondents, and a questionnaire. The non-sampling errors introduced by these three factors are often of greater consequence to the accuracy of a measure than is sampling variance (Converse and Traugott, 1986; Groves, 1989). Research on the measurement of non-sampling errors has been done by both the National Center for Health Statistics (NCHS) (Koons, 1973) and the Census Bureau (Lavin, 1989). Although studies of similar magnitude have not been done in veterinary medicine, a few notable examples do exist, including the documentation of non-response bias in a mail survey on dairy management (Cowen et al., 1986), and methodological studies evaluating reliability (Schukken et al., 1989), producer recorded data (Vaillancourt et al., 1990), and the validity of survey data (Morrow et al., 1992). Several survey statisticians have likewise addressed the issues of non-sampling error (Kish, 1965; Lavin, 1989). A comprehensive description of the sources of variable and fixed errors is provided by Groves (1989).

The total survey error for a given statistic is referred to as the mean square error. It consists of those errors which vary over hypothetical trials of a survey (variance) and those errors which are constant (bias) for all implementations of a survey (Kish, 1965; Farver, 1985; Groves, 1989). The sources of error are identical for both 'variance' and 'bias'. Groves defines errors of non-observation as "those arising because measurements were not taken on part of the population." These include coverage error, non-response error, and sampling error. He defines errors of observation as "deviations of the answers of respondents from their true values on the measure." The four components of the errors of observation are the

interviewer, the respondent, the questionnaire, and the mode of communication (mail, face, interview) (Groves, 1989).

Typically, the types of errors one is most concerned with relate to the intended use of the collected data. The two primary uses of data are descriptive and analytic. The greatest threat to 'describers' of a population are errors of non-observation such as non-coverage and non-response. Modelers are less concerned with these errors and are affected more by variables which are unreliable or of poor validity (Groves, 1989). NAHMS is in the unenviable position of catering to both types of uses. These differing expectations bring different concerns to the 'quality' of data collected, and this requires an assessment of total survey error and not merely errors of non-observation (i.e. non-coverage, non-response).

The results of these two follow-up studies will be used to address two important questions regarding the quality of data gathered by the NSS. First, are there any major differences between States in the implementation of the survey design put forth by NAHMS. Second, what is the effect of non-sampling error in the NSS.

2. Methods

A detailed description of the essential survey design used for the NSS has been published by NAHMS (USDA, 1992). In order to evaluate non-sampling error in the NSS and assess the variability in implementation between States, two questionnaires were administered at the conclusion of the national study (April 1991). These two questionnaires were distributed to the two stages of field implementation of the NSS: NAHMS coordinators and field Veterinary Medical Officers (VMOs).

The NAHMS coordinator questionnaire was handed to all coordinators during a session of the training workshop for the succeeding national dairy study 30 April to 3 May 1990. Coordinators completed questions regarding their livestock background, the training they received, their participation in field assignments, the training of VMOs, and the promotion of the NSS in their State. A series of open-ended questions were included to address certain areas of administration such as assignment of herds, review of questionnaires, data entry and validation, and additional policies established to implement the NSS in their State. A final section of the NAHMS coordinator questionnaire asked about their perception of VMO attitude and the validity of collected data.

VMO questionnaires were mailed to each coordinator to be distributed to VMOs in their respective States. This questionnaire provided a profile of the VMO, the farm visits, and the producer. Sections covering questionnaire administration and coding were included to allow an assessment of the sources contributing to non-sampling errors. For questionnaire administration, VMOs were asked how they read different types of questions. Some questions from the NSS were close-ended and the list of response categories was to be read to the respondent. Field-coded questions, however, were to remain open-ended without the reading of the list of response categories. Other questions were more complex in structure and repre-

sented multiple variables, or even a table of information to be completed. For the section on coding, questions were lifted off the original NSS questionnaire, with any directions pertaining to the reading or coding of the question removed. Questions from the NSS known to be troublesome (in the experience of the senior author) were selected, and an effort was made to provide simulated answers which were ambiguous, but also realistic. The VMO was asked how he/she coded such situations in the field. This provided a direct estimate of the level of misclassification for these variables in the NSS for those particular situations. A final section of the VMO questionnaire asked their opinions regarding the quality of data obtained from respondents.

Assessment of variation in survey administration at the coordinator level was restricted to a descriptive analysis of the NAHMS coordinator questionnaire. State effect was not tested for because of the small sample size (Table 1). For the VMO questionnaire, in addition to calculating the mean, the percent of VMOs who indicated that a particular situation never occurred is included. The mean values are for all VMOs, including responses equal to zero. The first four questions asked the VMO to indicate the number of farm visits on which a particular situation was encountered. Since these data were not normally distributed, ANOVA was not done for this section. For the rest of the variables ANOVA was conducted to test for significant State effects. The resultant F values are given in Table 2.

Response error was assessed by making use of repeated measurements. Ques-

Table 1
Prevalence of correlates of non-sampling error relating to the interview by visit (from the VMO questionnaire, Section II: Visit profile)

Variable	Mean	Percent of observations = 0
Number of visits where a substitute VMO was used		
First visit	0.15	93.7
Second visit	0.23	92.6
Third visit	0.19	92.6
Number of visits where multiple respondents were present		
First visit	1.02	45.8
Second visit	0.81	54.2
Third visit	0.73	56.3
Number of visits where a different respondent was interviewed on a subsequent visit		
First visit	0.07	94.8
Second visit	0.18	86.5
Third visit	0.11	90.6
Number of times the report was given to the producer prior to visit		
First visit	0.08	91.8
Second visit	1.87	64.9
Third visit	4.39	32.3

Table 2
Prevalence of correlates of non-sampling error related to the reading of the questions by questionnaire (from the VMO questionnaire, Section II: Visit profile)

Variable	Mean	Percent of observations = 0	*F*-test
Percent of Swine Health Report questions asked by			
Read verbatim	64.7	13.3	1.1
Paraphrased the same way	15.8	31.6	1.1
Paraphrased differently	9.8	69.7	0.6
Read by producer	13.5	62.6	0.8
Percent of Facilities and Feed Report questions asked by			
Read verbatim	65.3	16.2	1.2
Paraphrased the same way	12.8	67.7	1.2
Paraphrased differently	8.0	76.8	0.7
Read by producer	16.4	60.6	2.3
Percent of Ending Inventory and Economic Report questions asked by			
Read verbatim	58.8	21.2	0.8
Paraphrased the same way	12.5	71.7	1.6
Paraphrased differently	5.1	80.8	0.9
Read by producer	23.6	56.6	1.5

tionnaire design in the NSS included replication of indicators of the same concept within a questionnaire, as well as replication of identical measures over visits. There were 39 concepts from the NSS identified as having been measured by multiple questions; 14 of those were measured from the same questionnaire, and 25 were measured using different data collection instruments. An index of inconsistency was calculated for these variables, providing a measure of the reliability of the survey variables (Groves, 1989). As a measure of the reliability of a response, the index of inconsistency is the ratio of the variance of response errors to the total variance of the measure. A high index of inconsistency is associated with a high level of response error. The equation for a dichotomous variable was used as described by Groves.

3. Results

3.1. Coordinator questionnaire

Eighteen coordinators from 16 of the 18 States participating in the NSS responded to the questionnaire. Two States lost and replaced NAHMS coordinators during the study. All but two of the States began the study with coordinators who attended the NSS instructors workshop in the fall of 1989. Newly added coordinators were trained by other experienced coordinators. Seven States lost at least one VMO, with four losing two or more. At least eight States added a new

VMO during the study, with three of those States adding two or more (Table 3). New VMOs were trained by NAHMS coordinators if the new VMO had not received training in a previous State. Furthermore, many coordinators utilized 'hands on' training by accompanying some interviewers on farm visits (Table 3). The majority of interviewers used in the NSS were Federal and State VMOs (64% and 31% per State, respectively). Coordinators estimated that the majority of VMOs involved in the NSS had at least a moderately high interest in the program. However, according to coordinators, almost 20% of the VMOs had no interest in the program.

Most NAHMS coordinators carried out their responsibilities at the office (13/18), while some used their home (5/18). All but four coordinators assigned themselves at least one farm during the study, with coordinators monitoring 3.4 farms per quarter on average. Eight States relied primarily on producer publications, newsletters, and meetings to promote the NSS in their State. Newsletters

Table 3
Administrative differences between the 18 States in the 1990 National Swine Survey

State	New coordinator[a]	Lost VMOs[b]	New VMOs[c]	Promotion[d]	Support[e]	Joint visit[f]	Own farms[g]
01	N	N	N	N	N	N	Y
02	Y	Y	Y	N	N	N	Y
03	N	N	N	N	Y	N	Y
04	N	N	N	N	N	N	Y
05	N	Y	N	Y	N	Y	Y
06	N	Y	N	N	N	N	N
07	N	N	Y	Y	Y	Y	Y
08	N	Y	Y	N	N	N	N
09	Y	Y	Y	N	N	N	Y
10	N	N	Y	Y	Y	N	Y
11	Y	N	Y	N	N	N	Y
12	N	Y	N	N	N	N	Y
13	Y	N	N	N	N	N	N
14	N	N	Y	Y	Y	Y	Y
15	N	N	N	N	N	N	Y
16	N	N	N	Y	Y	Y	N
17	Y	N	N	Y	Y	N	Y
18	N	Y	Y	N	N	N	Y
Total 'Yes' responses	6	7	8	6	6	4	4

[a]Were new coordinators added during the NSS?
[b]Were any VMO positions vacated during the NSS?
[c]Were new VMOs added during the NSS?
[d]Were promotional efforts made for the NSS?
[e]Were other organizations actively involved in the NSS?
[f]Did coordinator accompany VMO on any farm visits?
[g]Did coordinator take on their own farm assignments?

were considered by coordinators to be most effective. Six States had no outside organization supporting the NSS, whereas other States benefited from active support of extension (6/18) or the university (5/18) (Table 3).

Several minor differences existed in the day-to-day administration of the NSS such as the distribution of herd assignments monthly or quarterly, the time and extent of initial review for completed questionnaires (seven reviewed on arrival, eight some time before data entry), the use of a data entry clerk (11), the establishment of written policies related to timely completion (11), and the use of additional worksheets by coordinators (13 States).

3.2. VMO questionnaire

The VMO questionnaire was completed by 99 of approximately 109 interviewers in 17 of the 18 States. A profile of VMOs indicated that over one-quarter of

Table 4
Interviewer perception of the quality of responses obtained from respondent (from the VMO questionnaire, Section III: Producer profile)

Variable	Mean	Percent of observations = 0	*F*-test
Change in quality of data collected			
Percent of farms showing decrease	16.0	64.9	1.0
Percent of farms showing no change	65.8	13.4	1.5
Percent of farms showing increase	17.9	58.8	1.3
Quality of estimate for questions on sq. ft. per building			
Wild guess	3.9	81.1	1.1
Good estimate	58.0	12.5	1.5
Exact calculation	38.5	35.8	1.0
Quality of estimate for questions on sq. ft per room			
Wild guess	3.2	83.0	1.0
Good estimate	55.7	12.6	1.7
Exact calculation	40.5	36.2	1.3
Quality of estimate for questions on farm expenditures			
Wild guess	18.1	55.3	1.3
Good estimate	50.6	21.1	1.3
Exact calculation	31.5	45.3	1.4
Quality of estimate for questions on hog inventory			
Wild guess	3.5	81.9	0.7
Good estimate	40.2	29.5	2.3
Exact calculation	56.4	22.1	1.9
Quality of estimate for questions on marketing of swine			
Wild guess	2.1	88.3	0.5
Good estimate	38.0	36.8	0.6
Exact calculation	60.2	21.1	0.6

Table 5
Number of VMOs using respective methods to administer questions with a list of response categories

Method of asking question	Swine Health Report		Facilities and Feed Report (2:9)[c]
	(3:2)[a]	(4:1)[b]	
Read the entire list of options	56	63	48
Read the first couple of options only	2	1	3
Read a sample of the options	14	17	19
Read none of the options	14	10	18
Other	13	8	10

[a]What vaccinations are used?
[b]What preventive practices are used?
[c]What types of waste management are used?

Table 6
Number of VMOs using respective methods to administer questions with a complex table structure

Method of asking question	Swine Health Report (4:4)[a]	Ending Inventory and Economic Report	
		(1:8)[b]	(1:10)[c]
Read leader question only	N/A	N/A	15
Ask the questions by column	36	39	34
Ask the questions by row	55	52	39
Other	7	7	10

[a]What services are provided by a: veterinarian? non-veterinarian?
[b]Interviewer asked percentage of pigs showing signs for table of diseases by stage of production.
[c]How many swine purchased and sold in the last 3 months were: (list of 13 classes of swine)?

Table 7
Percent of VMOs who miscoded given responses to selected questions from the National Swine Survey[a]

Question	Percent of VMOs miscoding response
Before entry to farm, is a shower required for employees?	26.6
Before entry to farm, is a shower required for feed delivery personnel?	39.8
Are there waterways or lakes/ponds present on this farm?	38.4
Have there been any problems of the muscles, bones, or joints?	67.4
How many gestating sows and gilts would be in the facilities at full capacity?	3.7
How many sq. ft. per animal are available in the facilities at full capacity?	51.3

[a]Note that this does not indicate the percent of responses misclassified for these questions.

the interviewers own livestock of some kind. Over 70% of VMOs had spent at least a year or more in food animal practice for an average of 8.4 years (median=4). The average time employed by State or Federal Department of Agri-

culture was 11.6 years (median = 6). There was no significant difference between States for either of these variables.

A summary of the information profiling the visit and the producer is given in Tables 1, 2, and 4. Only two variables showed a significant difference between States: whether or not the Facilities and Feed Report (FFR) and Ending Inventory and Economics Report (EIER) were given to producers prior to the appropriate visit (Table 2), and the interviewer's estimate of the quality of responses obtained for questions on the swine inventory (Table 4).

Tables 5 and 6 show that for a specific type of question, interviewers adopted different methods of administration. The proportion of VMOs using a particular method for administering a question is similar for each case investigated. This suggests that interviewers were consistent in their administration of questions with similar structure and across questionnaires. It is clear that on a whole the VMOs did not use a uniform method of delivering questions. These additional interviewer and respondent variations serve to decrease the precision of estimates. Of more serious consequence is the misclassification of responses by interviewers. Table 7 shows two instances where 26.6% and 39.8% of the VMOs misclassified a manufactured response to biosecurity questions taken from Section 1 of the SHR (specifically, the appropriate classification of responses into the 'No' vs. 'N/A' response categories). Calculations made in Section 6 of the FFR (square footage for facility types 'Open building: Access to dirt/concrete') also posed a problem, with roughly half of the VMOs including outside space in their calculations.

3.3. National swine survey

For multiple indicators of the same construct, the index of inconsistency was calculated to estimate the level of response error (Table 8). The first 14 indices look at the consistency of responses between similar questions within a questionnaire. For example, a farm responding 'Not Applicable' to a question of whether a change of coveralls is required of employees, stating in effect that they have no employees, should also respond 'N/A' to a question of whether a change of boots is required of employees. The indices ranged from 6.8 to 35.5, with most falling in the 20–35 range. Indices reported by the NCHS typically fall in the range 10–30. The rest of Table 8 calculates the inconsistency of responses for similar questions collected at different times. For example, a farm which indicates on the SHR that it routinely gives piglets an iron shot should also have recorded on the diary cards at least one piglet receiving an iron shot. For the consistency of reporting routine vaccination practices on the SHR and again at the time of blood collection, indices ranged from 69.8 to 113. For consistency of routine preventive practices reported in the SHR and diary cards, indices ranged from 39.4 to 92.8 for piglets and from 80.4 to 161.0 for sow/gilts.

Table 8
Index of inconsistencies for select variables from the National Swine Survey

	Variable name	Index of inconsistency
Repeat indicators within a questionnaire		
1	Breeding females separated vs. health tested	6.8
2	Breeding males separated vs. health tested	14.7
3	Feeder pigs separated vs. health tested	28.7
4	Employees required to shower vs. change boots	12.6
5	Feed delivery person required to shower vs. change boots	30.7
6	Livestock hauler required to shower vs. change boots	23.6
7	Visitors required to shower vs. change boots	20.5
8	Employees required to change boots vs. use footbath	27.5
9	Feed delivery person required to change boots vs. use footbath	22.9
10	Livestock hauler required to change boots vs. use footbath	21.5
11	Visitors required to change boots vs. use footbath	35.7
13	Access to nursery facilities by birds vs. rodents	32.2
14	Access to grower/finisher facilities by birds vs. rodents	35.5
Repeat indicators between questionnaires (vaccination practices)		
17	Vaccination for TGE	69.9
18	Vaccination for *E. coli* scours	80.0
19	Vaccination for rotavirus	76.2
20	Vaccination for *Clostridium perfringens*	69.6
21	Vaccination for *Hemophilus* pleuropneumonia	62.5
22	Vaccination for erysipelas	103.1
23	Vaccination for atrophic rhinitis	67.6
24	Vaccination for parvovirus	104.1
25	Vaccination for leptospirosis	113.2
26	Vaccination for PRV	75.2
Repeat indicators between a questionnaire and diary (preventive practices for piglets)		
27	Deworming	92.8
28	Mange/lice treatment	86.4
29	Clipping needle teeth	39.4
30	Docking tails	25.3
31	Iron shots	39.4
32	Castration	73.2
35	Coccidiostats	57.4
Repeat indicators between a questionnaire and diary (preventive practices for sows/gilts)		
36	Deworming	161.0
37	Mange/lice treatment	120.3
38	Antibiotics – feed	98.8
39	Antibiotics – water	102.1
40	Antibiotics – injection	112.2
41	Coccidiostats	80.4
42	Antibiotic in feed	79.4

4. Discussion

Prior to the start of the study in December 1989, a training workshop was held for the NAHMS coordinators (July 1989) from the 18 participating States (USDA, 1989a). The coordinators in turn held training sessions in their respective States for the field VMOs responsible for data collection (USDA, 1989b). These two tiers of information flow present opportunities for the alteration of the original design in an exponential fashion. For example, specific administrative details may be unintentionally omitted, the meaning and intent of questions or recording procedures may be misinterpreted, or unanticipated circumstances may arise in the field. The net effect is a less standardized mechanism for data collection than was initiated at the top of the study organizational pyramid. The reliance on health professionals without survey experience, where interviewing duties are only a part of their many responsibilities, assured a wide range of compliance with established guidelines for interviewing.

Training efforts for the NSS were extensive and have rarely been matched in previous VS animal health surveys. All coordinators and VMOs were exposed to detailed training handbooks put together by the NAHMS staff. (See NSS Technical Report for the evaluation results of training sessions.) Most coordinators adopted similar measures in the actual implementation of the NSS in areas, such as the promotion of NSS, the assignment of herds, the use of worksheets, etc. Likewise, for VMOs the interview situation, the delivery of questions, and their estimates of respondent data quality did not differ significantly between States.

Characteristics of the interview were measured to determine whether or not the measurement process was implemented as designed. Since many of the known causes of non-sampling errors are related to the interviewers (VMOs), they are a valuable source for identifying the presence of, and reason for, such errors (Lavin, 1989). These effects can be attributed to social influences affecting interviewer–respondent interaction, the different ways the interviewer administers the questionnaire, and their varying abilities to assist a respondent (e.g. probing).

Situations which did occur frequently that may affect the survey interview was the presence of more than one respondent. Half of the interviewers had about one farm, on average, where this situation was encountered. The presence of a relative or employer is likely to affect the responses given in an interview (Cannell, 1977). The interviewing of different respondents on subsequent visits occurred infrequently (Table 1). According to the VMOs, over 30% of respondents showed a change in the quality of data collected over the 3 month study (Table 2). With the exception of farm expenditures, very few quantitative responses were considered to be of poor quality. The inherent effects of the respondent as an essential part of the interview are confounded with the simple response variance of a respondent and the quality of responses given. Many of the situations in which a respondent may introduce error into a study can be controlled by the interviewer.

The interviewers themselves can introduce non-sampling error into a study. Certain interviewer characteristics (e.g. gender, race) affect respondent answers

(Cannell, 1977; Groves,1989). In a rural environment, the age and farm experience of the interviewer may affect the quality of estimates obtained from the respondent by influencing the interaction between them. No attempt was made to associate these interviewer demographic characteristics with data quality. Interviewer effects likely to have a larger effect on variable error are the inappropriate reading of questions and coding of responses (Cannell, 1977; Groves, 1989). Inconsistent wording of questions occurred most frequently for the SHR (9.85% of questions vs. 8% and 5% for FFR and EIER, respectively). A likely explanation is the subjective nature of Section 2 of the questionnaire, inviting increased latitude in both wording of the questions and coding of responses. Table 5 shows that the questions lifted from this section produced the greatest amount of misclassification. This agrees with findings in the North Carolina reliability study (Bush et al., 1993).

The effects of respondent and interviewer are often intertwined with the questionnaire structure and the wording of the questions. Subjective and ambiguous questions invite larger respondent and interviewer effects. Furthermore, complex question structure can adversely affect the interviewer–respondent interaction. The EIER experienced a large number of interviewers resorting to showing the question to the producer. A likely explanation is the complex structure of most of the questions, which were laid out in table formats. The result was a combination of error sources from the questionnaire itself (leading to variations in mode of communication), as well as interviewer and respondent effects.

Finally, another source of non-sampling error is the effect of the mode of communication. Given identical respondent and questionnaire, responses will vary depending on the mode of communication (mail, phone, face-to-face interview) (Groves, 1989). Approximately 25% and 60% of the FFR and EIER, respectively, were given to the producer prior to the visit. In many cases, this resembles a mail survey instead of a face-to-face interview.

Calculation of the index of inconsistency revealed a moderate level of response error for similar questions within the same questionnaire. A greater response error was noted for multiple indicators from different questionnaires. It is reasonable to expect better consistency of responses within an interview than between interviews. Further study is needed to determine factors influencing this index. It is possible that the miscoding of responses contributed to the response variance affecting these measures. For those questions comparing stated vaccination practices for the farm, and whether a particular sow was vaccinated, inconsistency tended to be high. This high level of response error documents the ecologic fallacy of farm-level data on preventive practices. As pointed out by Waltner-Toews et al. (1986), there is often a discrepancy between farm policy and the application of that particular practice to an individual animal. The discrepancies in this study can be attributed to a large number of farms which responded 'Yes' to the use of vaccinations on the SHR, yet were classified as 'No' for at least one sow being vaccinated based on the diary card data. Although no more than ten sows were sampled for blood collection, they were typically a representative sample and

should be of sufficient number to be exposed to routine practices. What remains undetermined in this investigation is whether the individual sows failed to be vaccinated despite a farm policy of vaccination, or if there was simply a failure to record individual vaccination on the diary cards. The same pattern existed for routine preventive practices. Practices which were common for most farms, such as clipping needle teeth, docking tails, and giving iron shots, had lower consistency between stated policy and recorded practices. Many factors may attribute to this high level of error. Some routine preventive practices may be performed only 2–3 times a year (e.g. deworming and mange/lice treatment) and therefore may not have been done during the 3-month study period. Other practices, however, may be stated as being a routine practice when in fact they are not.

5. Conclusion

The post survey questionnaires in this study substantiate the opportunities available for error to affect the validity of statistics/estimates via effects ushered in from the respondent, the interviewer, the questionnaire, or the mode of communication. Evaluating correlates of measurement error can shed further light on the validity of a study and point to the areas requiring better design, planning, or training. Empirical measures exist for assessing measurement error such as unit and item non-response and the index of inconsistency. Further research is needed to study the association of these correlates with empirical measures of error (e.g. response rates, index of inconsistency).

While few significant differences in administration of the NSS are evident at the State level, they do show considerable variation at the interviewer level. The interaction of the interviewer, respondent, and questionnaire provides an opportunity for non-sampling errors. The ability to evaluate correlates of these errors and even to obtain empirical assessments of measurement error should be taken into account in a greater number of epidemiological studies. Sampling error is an inadequate measure of total survey error. Greater application of these techniques, common in other disciplines, needs to become routine in the realm of veterinary epidemiological studies.

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